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Four new species of *Punctelia* from São Paulo State, Brazil

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Abstract — The following new species of *Punctelia* are described from remnant cerrado forests in São Paulo State, Brazil: *Punctelia crispa*, *P. digitata*, *P. imbricata*, and *P. roseola*. A key to the seven species of *Punctelia* found in the study area is presented.

Keywords — *Punctelia colombiana*, *Punctelia constantimontium*, *Punctelia fimbriata*, *Punctelia graminicola*, *Punctelia rudecta*, *Punctelia appalachensis*

Introduction

The Brazilian cerrado is included in the savanna world biome. It is recognized as one of the world's five hot spots of biodiversity and threatened vegetation (Fonseca et al. 1999). Cerrado formation is structurally and physiognomically heterogeneous, varying from grasslands (campo limpo) to arboreal structures (cerradão) (Coutinho 1978).

In São Paulo State, cerrado vegetation originally occupied 20% of the territory, but at present only ca. 1% of the original area remains (Zorzetto et al. 2003). In an ongoing effort to describe and document the biodiversity of the lichenized mycota, a survey of *Parmeliaceae* in remnant cerradoes in inland São Paulo State was performed (Jungbluth 2006). Several new species were recognized, as expected in such a diverse biome (Jungbluth et al. 2008).

Thirty species of *Punctelia* are known worldwide (Egan & Aptroot 2004), sixteen of which are recorded for Brazil (Marcelli 2004). In addition, two further Brazilian species were described recently (Canêz & Marcelli 2007).

This present paper describes four new *Punctelia* species from areas of cerrado in São Paulo State and provides an identification key for the seven species found in this vegetation type.

Material and methods

The specimens were collected in cerrado remnants in central-east São Paulo State. All the cerrado physiognomies present in the area were investigated. For more information and a map with the localities, see Jungbluth et al. (2008).

In this paper, PHYLLIDIA are considered to be dorsiventral, secondary projections that differ anatomically from the thallus, chiefly by lacking a lower cortex; LACINULES are narrow, secondary structures (reproductive or vegetative) having the same anatomic organization as the thallus that are longer than wide and distinguished from LOBULES, which are wider than long and possess rounded apices. We consider any structure SOREDIOID if it is composed of heaped soredia.

The chemistry of the thallus was determined through color reactions (spot tests) and thin layer chromatography (TLC) in solvent C, using methodology adapted from Bungartz (2001) and following the recommendations and data from Walker & James (1980), Huneck & Yoshimura (1996) and Orange et al. (2001). High performance liquid chromatography (HPLC) was performed on holotype specimens (Elix et al. 2003).

The diagnoses refer exclusively to the holotypes while the English technical descriptions refer to all the studied material.

Results and discussion

Although individual thalli may be locally common, in general species of *Punctelia* are not easily found inside cerrado forests where they are apparently somewhat limited to well lit but not directly illuminated microhabitats.

The vegetative reproductive structures found in *Punctelia* species most frequently originate from the margins of the pseudocyphellae. True soredia, isidia, and lobules are very rare in *Punctelia*, and the origin and development of vegetative propagules differs significantly from those commonly found in most of the other parmelioid genera. Therefore, it is necessary to be careful in applying indiscriminately the above terms and it must be understood that they are used by analogy because more appropriate terms are not available.

Seven taxa were found in the region investigated: *P.* cf. *graminicola* (B. de Lesd.) Egan, *P. punctilla* (Hale) Krog, *P. reddenda* (Stirt.) Krog, and four species new to science, described below as *P. crispa, P. digitata, P. imbricata,* and *P. roseola*.

Key to *Punctelia* species found in the São Paulo State cerradoes

1a. Lower surface dark brown to black at least in the center 2
1b. Lower surface white to pale brown throughout 4

2a. Lobules present ..... *P. imbricata*
2b. Lobules absent 3

3a. Soredia absent, isidia present, medulla C+ rose, KC+ rose ..... *P. roseola*
3b. Soredia present, isidia absent, medulla C–, KC– ..... *P. reddenda*

4a. Margin crispate, ornamented with lobules/phyllidia ..... *P. crispa*
4b. Margin entire, lobules absent 5

5a. Isidia present, lacinules absent ..... *P. punctilla*
5a. Isidia absent, lacinules present 6

6a. Lacinules palmately branched ..... *P. digitata*
6b. Lacinules irregularly branched ..... *P.* cf. *graminicola*

The new species

Punctelia crispa Marcelli, Jungbluth & Elix, **sp. nov.** Fig. 1

MB 512456

Diagnosis: *Affinis* Punctelia fimbriata *sed margine thalli et pseudocyphellis, structuris soredioideis non corticatis instructis differt.*

Holotype—Brazil, São Paulo State, Campo Limpo Paulista Municipality, Botujuru quarter, 23°14'S 46°46'W, 750 m alt., orchard in a small farm located in a mesophyllous forest – cerrado forest transition, on tree trunk, leg. M.P. Marcelli & A.E. Luchi 17601, 20-IV-1980 (SP, isotype in F).

Thallus grayish, corticolous, lobate, loosely adnate, to 10 cm wide. Lobes irregularly branched, contiguous, 1.5–4.0 mm wide at the base, 2.0–4.0 mm maximum width; apices rounded; margin crenate, ascending, undulate and crispate at least in the proximal areas; upper surface continuous, smooth; maculae faint, punctiform to sublinear, submarginal, soon forming pseudocyphellae; pseudocyphellae orbicular, rarely ellipsoid, with elevated borders when old; near the margin 0.15–0.60 mm wide, elsewhere up to 1.30 mm wide. Pustules, lacinules, lobules and isidia absent. Phyllidia erect, sorediod (disintegrating into piles of soredia when young or after ramifying), small, 0.1–0.6(–0.8) × 0.1–0.2 mm, irregular in shape, occasionally with an eroded surface, irregularly branched, developing from the margins of lobes and pseudocyphellae. Soredia coarse, originating from disintegrating phyllidia and forming rounded structures ca. 0.2(–0.3) mm diam. on the pseudocyphellae or having the shape of ramified phyllidia whose density gives the proximal parts of the thallus a crispate appearance. Medulla white. Lower surface mostly naked, dull, pale brown in the distal parts but dark brown in the proximal parts; rugose and veined; marginal zone erhizinate but sometimes papillate,

1.5–4.0 mm wide; RHIZINES pale brown or concolorous with the lower surface, simple to sometimes sparingly branched, 0.2–1.5 mm long, mostly grouped in the central portion of the lobes. APOTHECIA and PYCNIDIA not seen.

COLOR REACTIONS: upper cortex K+ yellow, UV–; medulla K–, C+ rose, KC+ rose, P–, UV–.

TLC/HPLC: atranorin (minor), gyrophoric acid (major), lecanoric acid (trace).

COMMENTS– *Punctelia crispa* has characteristic, ascending, undulate and crispate lobe margins (hence the specific epithet), ornamented by phyllidia, and producing soredia and soredioid structures analogous to those found in some species of *Cladonia*. The borders of the pseudocyphellae and the margins of the lobes, particularly the proximal ones, disintegrate at some points and erode, assuming a very uneven appearance and forming heaped soredioid structures, resembling eroded lobules or fringes, which can become erect, ramified or even flattened, but never corticate.

The true phyllidia present in *P. fimbriata* Marcelli & Canêz give this species a very similar crispate appearance. However, the lobes of *P. fimbriata* have a black lower surface with a narrow, brown margin, and the holotype (SP!) has smaller pseudocyphellae [0.05–0.12(–0.20) mm diam.] with no obvious elevated margins.

Punctelia stictica (Delise ex Duby) Krog (G, holotype!) exhibits irregularly aggregated soredia ca. 0.1 mm diam. which become granular. The lower surface is dark brown to black.

Punctelia missouriensis G. Wilh. & Ladd (IMI, isotype!) forms clustered granules which sometimes resemble isidioid structures, but it has a cracked upper surface, unornamented lobe margins and produces lecanoric acid as a major medullar component.

Punctelia digitata Jungbluth, Marcelli & Elix, **sp. nov.** FIG. 2

MB 512457

DIAGNOSIS: *Affinis* Punctelia graminicola *sed lacinulis digitiformibus presentibus differt.*

HOLOTYPE—Brazil, São Paulo State, Itirapina Municipality, 22°15'S 47°49'W, 770 m alt., Estação Experimental do Instituto Florestal, Pedregulho, cerradão forest, on tree trunk, leg. P. Jungbluth, A.A. Spielmann & L.S. Canêz 807, 24-III-2004 (SP, isotype in ASU).

THALLUS grayish, lobate, adnate, 4.5–10.0 cm wide. LOBES irregularly branched, contiguous, 0.5–3.0 mm wide at the base, 2.0–4.0 mm maximum width, apices rounded; margin crenate to dentate or lacinulate; upper surface continuous or sometimes irregularly cracked, smooth. MACULAE faint or distinct, irregular, marginal, developing pseudocyphellae. PSEUDOCYPHELLAE laminal and marginal, mostly orbicular, plane to excavate, emarginate, 0.05–0.20 mm diam.,

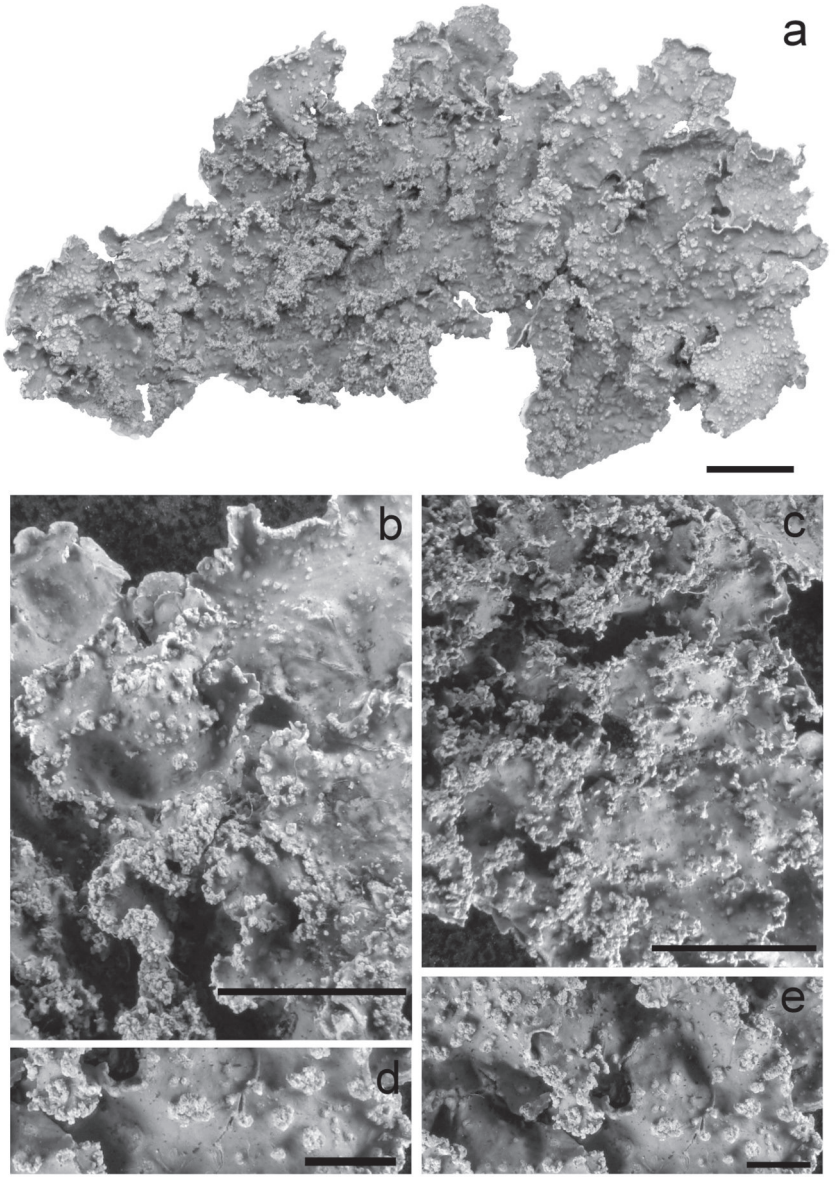

Figure 1. *Punctelia crispa* holotype.
a. Part of the holotype. b. Young part of the thallus and crispate margin.
c. Older part of the thallus. d, e. Soredia and crispate margin initial formation.
Bars: a,b,c = 5 mm; d,e = 2 mm.

hidden by lacinules in the proximal region. Pustules, lobules, phyllidia, soredia and isidia absent. Lacinules abundant on the margins of lobes and older pseudocyphellae, 0.1–0.8 × 0.1–0.2 mm, flat and prostrate, simple to irregularly branched or commonly palmate, apices acute to truncate, sometimes with apical pseudocyphellae. Medulla white. Lower surface white to very faint brown, shiny, smooth to slightly rugose; marginal zone white to shiny olivaceous or bluish, 1.0–4.0 mm wide, with a gradual change of color from the margin to the center, smooth to veined; erhizinate margin 0.5–2.0 mm wide; rhizines concolorous with the lower surface, simple or rarely irregularly branched, 0.2–1.5 mm long, abundant, evenly distributed. Apothecia and Pycnidia not seen.

Color reactions: upper cortex K+ yellow, UV–; medulla K–, C+ red, KC+ red, P–, UV–.

TLC/HPLC: atranorin (trace), lecanoric acid (major).

Paratype—Brazil, São Paulo State, Itirapina Municipality, 22°15'S 47°49'W, 770 m alt., Estação Experimental do Instituto Florestal, Pedregulho, cerradão forest, on tree trunk, leg. P. Jungbluth, A.A. Spielmann & L.S. Canêz 805, 24-III-2004 (SP).

Comments– *Punctelia digitata* has characteristic, palmately branched reproductive lacinules that resemble prostrate, ±imbricate, flattened isidia which originate from the margins of the lobes and pseudocyphellae. This species has a white to pale brown lower surface and lecanoric acid in the medulla. The mature pseudocyphellae are orbicular and excavate; the older ones may give rise to cracks.

Punctelia graminicola has irregularly branched, flat vegetative lacinules, which develop at the truncate apices of the main lobes (ASU, lectotype!).

Punctelia punctilla, *Punctelia rudecta* (Ach.) Krog and *Punctelia subflava* are three further species with a pale lower surface and medullary lecanoric acid.

Punctelia punctilla (LD, holotype!) differs from *P. digitata* in its isidioid phyllidia that never become soredioid [although Krog (1982) and Riefner (1989) describe the isidia as papilliform, sparsely branched, with an opaque surface and which may become almost coralloid with age].

Punctelia rudecta has clustered simple to branched cylindrical isidia (H-Ach 1337, holotype!), which are sometimes said to become squamuliform and dorsiventral (Krog 1982, Ferraro 1986), but never assume the typical digitate structures found in *P. digitata*.

Unlike *P. digitata*, *Punctelia subflava* has an upper surface that is typically subscrobiculate near the margins and develops marginal lobules and sparsely ramified phyllidia less than 0.6 mm long (FH, holotype!) that are often mainly lobate-squamuliform and spread over the lamina of the older lobes (Elix & Johnston 1988, Elix 1994).

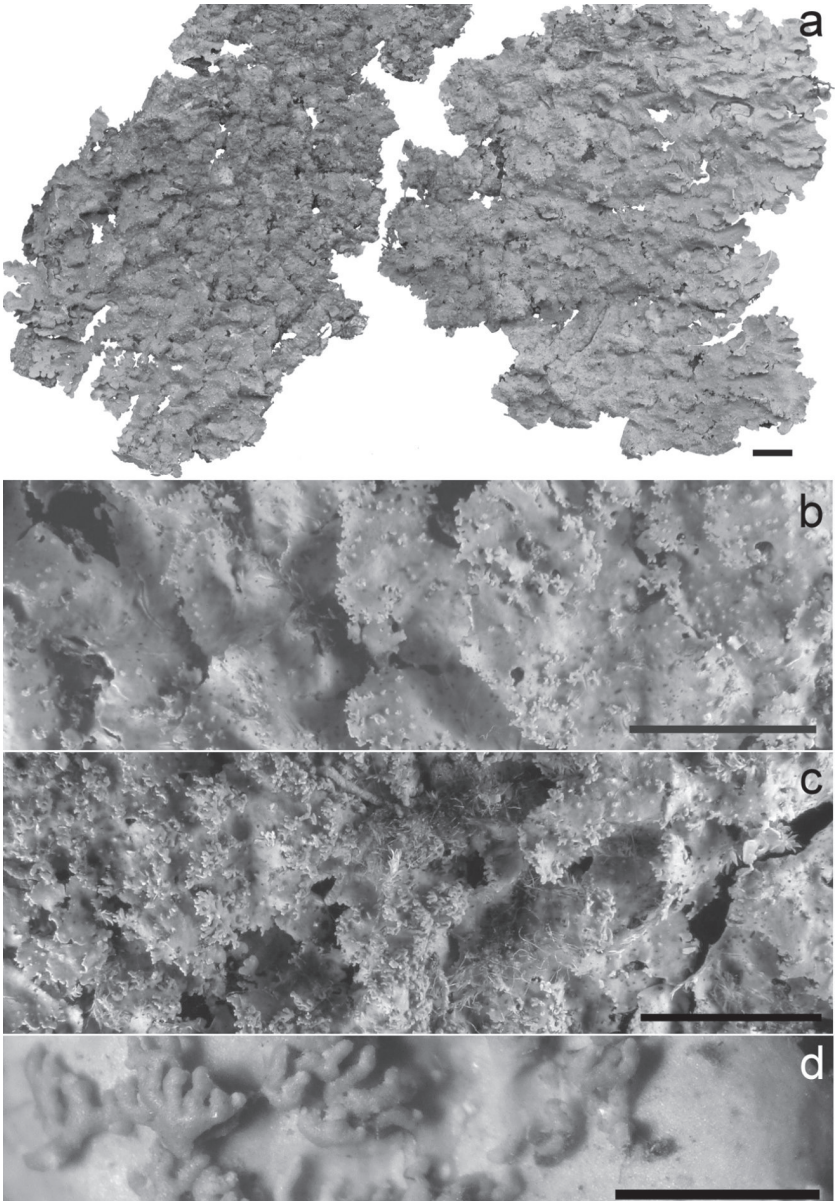

Figure 2. *Punctelia digitata* holotype.
a. Part of the holotype. b. Young part of the thallus.
c. Older part of the thallus. d. Detail of the palmate lacinules.
Bars: a,b,c = 5 mm; d = 1 mm.

Punctelia appalachensis (W.L. Culb.) Krog (DUKE, holotype!; H, isotype!), which produces protolichesterinic acid in medulla (C–), has a very similar general habit and palmate propagules but with a black lower surface and the lacinules that are erect and commonly longer than 1 mm, in contrast to the prostrate lacinules up to 0.8 mm long in *P. digitata*.

The specific epithet refers to the shape of the lacinules present in this species.

Punctelia imbricata Marcelli, Jungbluth & Elix, **sp. nov.** Fig. 3

MB 512458

Diagnosis: *Affinis* Punctelia constantimontium *sed lobis majoribus et lobulis subtus non erosis differt.*

Holotype—Brazil, São Paulo State, Campo Limpo, Paulista Municipality, Figueira Branca, 23°12'S, 46°47'W, 750 m alt., orchard inside a small farm, on trunk of *Mangifera indica* in a shaded and humid place, leg. P. Jungbluth 1079, 13-V-2004 (SP, isotypes in B and S).

Thallus greenish grey, lobate, adnate, 15–20 cm wide. Lobes irregularly branched, contiguous to overlapping laterally, 2.0–4.0 mm wide at the base, 4.5–8.0(–10.0) mm maximum width, apices rounded; margin crenate to crenulate or irregularly incised; upper surface continuous, smooth, becoming slightly rugose with age; maculae absent; pseudocyphellae punctiform, laminal and marginal, flat to slightly elevated, not excavate, 0.1–0.3 mm diam. Pustules, lacinules, phyllidia, soredia and isidia absent. Lobules abundant, mostly roundish, usually convex but some flat or concave, 0.3–1.5 × 0.2–1.0(–3.0) mm, ascending to ±procumbent and imbricate, simple to irregularly branched, rarely incised, growing from the upper surface (not from the pseudocyphellae) and proliferating to produce more lobules, with marginal pseudocyphellae, some developing rhizines. Medulla white. Lower surface black, dull, smooth to rugose and veined; marginal zone faint brown, shiny, 1.5–3.5 mm wide, well delimited from the center, papillate, without rhizines, 1.5–3.0 mm wide; rhizines whitish and cream, blackened in just a few areas at the center of the thallus, simple, 0.1–0.5 mm long, frequent, grouped. Apothecia not seen. Pycnidia mainly on the lobules; conidia unciform, 4–6 × ca. 1 μm.

Color reactions: upper cortex K+ yellow, UV–; medulla K–, C+ rose, KC+ rose, P–, UV–.

TLC/HPLC: atranorin (trace), gyrophoric acid (major), orcinyl lecanorate (minor), lecanoric acid (trace).

Comments– *Punctelia imbricata* is characterized by the ascending to imbricate, laminal lobules that do not originate from pseudocyphellae, the black lower

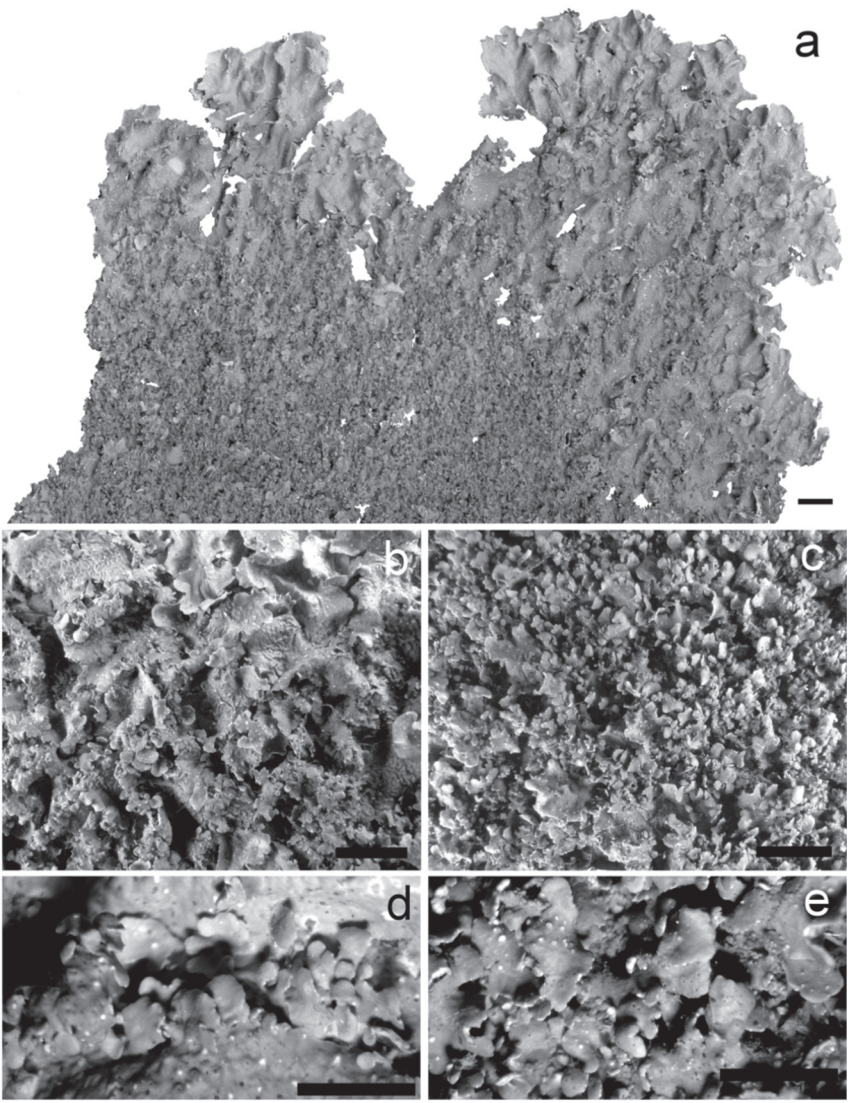

Figure 3. *Punctelia imbricata* holotype.
a. Part of the holotype. b. Young part of the thallus.
c. Older part of the thallus. d, e. Detail of the lobules.
Bars: a,b,c = 5 mm; d,e = 2 mm.

surface, 4–6 µm long unciform conidia, and the presence of gyrophoric acid as the major medullary substance. The pseudocyphellae are punctiform or rarely elliptical, plane at first but then somewhat elevated.

Punctelia constantimontium Sérus. differs in having narrower lobes (less than 3 mm wide) and lobules up to 0.1–0.4(–0.8) mm long and with eroded lower cortex. The lower surface of the lobules in *P. imbricata* is corticate, and some develop rhizines. Furthermore, the pseudocyphellae of *P. constantimontium* are smaller [0.05–0.1(–0.3) mm in diameter] and laminal, and only rarely develop on the lacinules (BM, holotype! and L.S. Canêz pers. comm.)

Despite the similar original description (Sérusiaux 1984), *P. colombiana* Sérus. has isidia which are associated with the pseudocyphellae and become flattened, and this species produces filiform conidia (S, holotype! and L.S. Canêz pers. comm.).

Punctelia roseola Jungbluth, Marcelli & Elix, **sp. nov.** Fig. 4

MB 512459

Diagnosis: Affinis Punctelia colombiana sed margine integra, isidiis cylindricis instructis et substantias butlerinas continente differt.

Holotype—Brazil, São Paulo State, Jurumirim Municipality, 23°11'37"S 49°17'46"W, 535 m alt., about 300 m from Tietê River margin, a large isolated tree in a pasture on a small farm, in a dry, clear place without direct sunlight, corticolous, leg. M.P. Marcelli, J. Vieira Filho & F.A.S. Berchez 17578, 20-VI-1979 (SP, isotype in BM).

Thallus gray but becoming tan in the herbarium, lobate, adnate, 10–20 cm wide. Lobes irregularly or rarely dichotomously branched, contiguous to overlapping laterally, 2.5–6.0 mm wide at the base, 4.0–9.0 mm maximum width, apices rounded; margin crenate, undulate; upper surface continuous, smooth to slightly notched in the center of the thallus; maculae absent; pseudocyphellae orbicular, laminal, convex, 0.05–0.15 mm wide. Pustules, lacinules, phyllidia, lobules and soredia absent. Isidia concolorous with the upper surface, originating as granules along the margins of the pseudocyphellae, soon expanding to form cylindrical, slightly moniliform and irregularly branched structures, which become somewhat flattened and dorsiventral with age, 0.2–0.5 mm long, erect, laminal, mainly in the center of the thallus. Medulla white to very faint rose. Lower surface pale to dark brown (almost black) in the center, dull, rugose and papillate; marginal zone brown, 1.0–3.0 mm wide, dull, smooth to papillate and veined, the erhizinate portion 1.5–2.5 mm wide, shiny; rhizines cream, darkening in the center of the thallus, simple, 0.2–0.6 mm long, frequent to abundant, evenly distributed. Apothecia immature, concave, 1.0–3.0 mm wide, sessile, laminal, margin smooth, amphithecium pseudocyphellate, disc dark brown, imperforate; ascospores not seen. Pycnidia submarginal; conidia filiform, (6–)8–11 × ca. 1 µm.

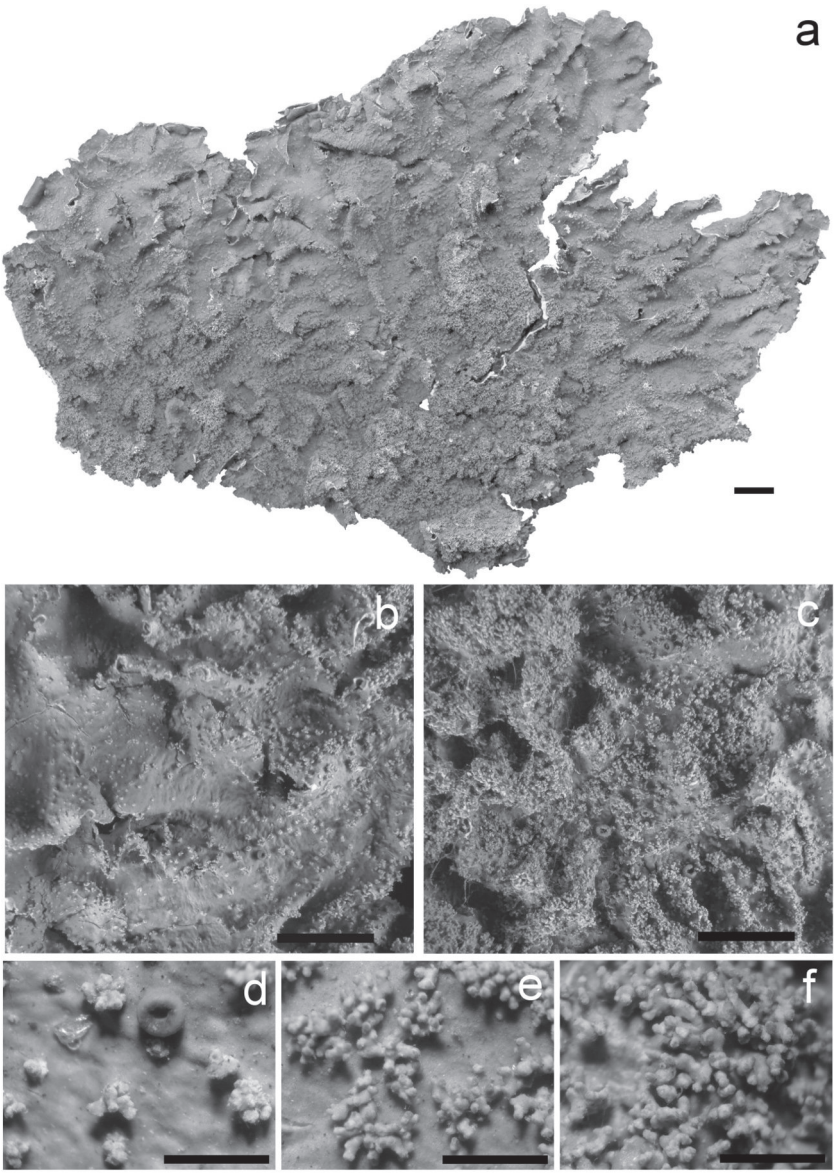

Figure 4. *Punctelia roseola* holotype.
a. Part of the holotype. b. Young part of the thallus.
c. Older part of the thallus. d, e, f. Stages of isidia development.
Bars: a,b,c = 5 mm; d,e,f = 1 mm.

Color reactions: upper cortex K+ yellow, UV–; medulla K+ faint rose, C+ rose, KC+ rose, P–, UV–.

TLC/HPLC: atranorin (minor), gyrophoric acid (major), butlerin D (submajor), lecanoric acid (minor), butlerin A, butlerin B, butlerin E, butlerin F (all minor).

Paratypes—Brazil, São Paulo State, same locality and habitat as the type, leg. M.P. Marcelli, J. Vieira Filho & F.A.S. Berchez 17574 (SP), 17575 (B, H), 17576 (SP), 17577 (SP), 17580 (NY), 20-VI-1979.

Comments — *Punctelia roseola* is characterized by its unique pale rose medulla (can be mistaken by white without a good white illumination) associated to irregularly branched "isidia", a pale- to dark brown lower surface, filiform conidia 6–11 µm long, medullary gyrophoric acid and butlerins.

The pseudocyphellae are orbicular, laminal, convex, and very soon obscured by isidia.

This species is very similar to *P. colombiana* in the distribution and shape of the cylindrical isidia that become flat and dorsiventral; however, those of *P. colombiana* have eroded lower cortices. Furthermore, *P. colombiana* has a black lower surface with a narrow, dark brown marginal zone (S, holotype!), while *P. roseola* has a dull brown lower surface which ranges from very pale brown at the margin to dark in the center, without a distinct marginal zone.

Punctelia stictica (G, holotype!) has a dark lower surface, medullary gyrophoric acid and similar conidia to those of *P. roseola*; however, *P. stictica* produces granular soredia that sometimes develop into pseudoisidia.

Punctelia constantimontium (BM, holotype!) and *P. imbricata* also have a black lower surface and medullary gyrophoric acid, but both produce lobules and have unciform conidia.

The epithet refers to the color of the medulla and the two larger TLC spots (butlerins).

Acknowledgements

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